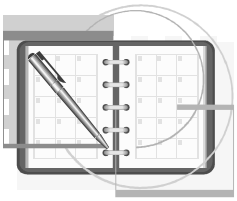
California Air Resources Board

Tire Pressure Regulation to Reduce Climate Change Emissions

Public Workshop
October 8, 2008

Agenda



- Introduction
- Background
- Overview
- Regulatory Concepts
  - Check and Inflate
  - Inflation Pressure Loss Rate (IPLR)
  - Alternatives Considered
- Emission Inventory
- Emission Benefits
- Regulatory Costs
- Cost-Effectiveness
- Enforcement
- Outreach
- Timeline

Background

- Global Warming Solutions Act (AB32)
- Reports/Stakeholder Input/Meetings
  - California Inspection and Maintenance Review Committee (IMRC)
  - National Highway Traffic Safety Administration (NHTSA)
  - California Integrated Waste Management Board (CIWMB)

Background

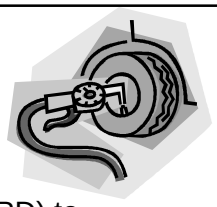
- Reports/Stakeholder Input/Meetings (continued)
  - ExxonMobil Chemical
    - Inflation Pressure Retention Effects On Tire Rolling Resistance, Vehicle Fuel Economy and CO2 Emissions
    - 10th Worldwide Tire Survey: Replacement Tires
  - Survey conducted by the Rubber Manufacturer's Association
  - Two workgroup meetings held in March and June 2008

Overview
Regulatory Assumptions

- Proposed regulations will reduce CO_2 emissions by reducing fuel consumption

- Properly inflated tires helps reduce fuel consumption by reducing rolling resistance

Regulatory Concepts
Check and Inflate



Requirements

- Will require Automotive Repair Dealers (ARD) to perform a tire check and inflate service as part of every maintenance or repair service

- Example of ARD's affected:
  - oil change facilities, dealerships, independent garages, smog check stations, tire facilities

- Example of ARD's not affected:
  - Collision & Auto-body shops, auto paint shops, auto glass repair businesses

Regulatory Concepts
Check and Inflate

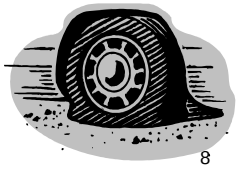
Concerns to date

- Liability
  - Tire Guide/Yearbook
  - Tire gauge standard
  - Properly inflated tires provide optimal safety benefits
- Exemptions will not be provided
- Costs

Regulatory Concepts
Inflation Pressure Loss Rate

Requirements

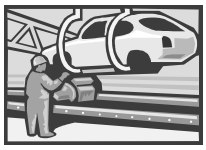
- Will require tire manufacturers to reduce Inflation Pressure Loss Rates (IPLR) for passenger cars and light-duty and medium-duty vehicle tires sold in California.
- IPLR performance standard will be based on cost-effectiveness and technical feasibility



Regulatory Concepts
Inflation Pressure Loss Rate

Assumptions

- IPLR → Improves Rolling Resistance → Improves Fuel Efficiency
- One of the world's leading automakers
  - 2.5% loss/month or better IPLR Standard
  - OE tires worldwide



- ASTM F1112-06 "Standard Test Method for Static Testing of Tubeless Pneumatic Tires for Rate of Loss of Inflation Pressure"
  - Used to measure IPL rate (% per month)
  - Auto and Tire Industry involved in developing test
  - Already used by many tire manufacturers

Regulatory Concepts
Inflation Pressure Loss Rate

Concerns

- Testing Procedure
  - Certification
  - Length of Testing
  - Inflation medium used for testing
    - "Dry Air" vs. "Shop Air"
    - "Dry Air" used to standardize test

Regulatory Concepts
Alternatives Considered

Nitrogen
- Provides Pressure Retention Benefits
- Cost-Effectiveness
  - ~$416 million initial capital investment ($6,500 x 44,000 ARD's+20,000 gas stations)
  - ~$92 to $161 million initial cost to consumer

Tire Pressure Monitoring Systems (TPMS)
- Limited Aftermarket Equipment
- Designed to improve safety not fuel efficiency
- Estimated ~$5.4 billion initial capital cost to consumer ($257 x ~21 million vehicles w/out TPMS)

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Emissions Inventory
(Without Regulation)

Assumptions
- Automobiles a major source of CO_2 emissions
- CO_2 production from automobiles is directly proportional to fuel consumed
  - One gallon of gasoline consumed produces ~19.4 lbs of CO_2
- Approximately 23 million registered light and medium-duty vehicles in California

Emissions Inventory
(Without Regulation)

- Utilized ARB's EMission FACtors Model (EMFAC2007)

- EMFAC2007:
  - Latest computer model that can estimate California emission rates for on-road mobile sources for years 1970 to 2040
  - Reflects ARB's current understanding of vehicle travel and emissions generated

Emissions Inventory
(Without Regulation)

- EMFAC2007 utilized to forecast:
  - Passenger cars/light-duty vehicles population
    - < 5750 lbs. GVWR (Toyota Camry)
  - Medium-duty vehicle population
    - 5751 – 8500 lbs. GVWR (Ford Expedition)
  - Annual Fuel Consumption
  - Annual CO_2 Emissions
- Projected for years 2010 to 2020
  - Increase in emissions due to forecasted increase in vehicle population and miles traveled

Emissions Inventory
(Without Regulation)

- In 2010:

	Number of Vehicles	Fuel Consumption (gallons/year)	CO2 Emissions (MMT/year)
Light-Duty Autos	13,551,100	7.2 billion	63.1
Light-Duty Trucks 1	2,956,830	1.9 billion	17.0
Light-Duty Trucks 2	5,622,180	4.0 billion	35.1
Medium-Duty Vehicles	2,468,110	2.5 billion	21.8
Total	**24,598,220**	**15.6 billion**	**137.0**

- In 2020:

	Number of Vehicles	Fuel Consumption (gallons/year)	CO2 Emissions (MMT/year)
Light-Duty Autos	15,695,300	8.0 billion	71.3
Light-Duty Trucks 1	3,480,900	2.3 billion	20.3
Light-Duty Trucks 2	6,644,750	4.6 billion	40.3
Medium-Duty Vehicles	2,953,680	2.8 billion	24.6
Total	**28,774,630**	**17.7 billion**	**156.5**

Emission Benefits
Check and Inflate

Overview

- Emission reduction based on the potential fuel savings with the implementation of proposed regulation

- Fuel savings:
  - Difference between gas consumption without regulation and gas consumption with regulation

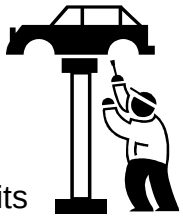
Emission Benefits
Check and Inflate

- NHTSA Tire Pressure Study, vehicles with under-inflated tire (average of all 4 tires)
  - 54% of Passenger Cars
  - 62% of Light/Medium-Duty Trucks

- Passenger
  - 20% Severely (≥6 psi under-inflation)
    - Average 8.7 psi under-inflation
  - 34% Moderately (>1 psi and <6 psi)
    - Average 2.9 psi under-inflation

- Light/Medium-Duty Trucks
  - 26% Severely under-inflated
    - Average 8.5 psi under-inflation
  - 36% Moderately under-inflated
    - Average 3.0 psi under-inflation

Emission Benefits
Check and Inflate



Assumptions

- Vehicle maintenance patterns, shop visits
  - Estimated 3 times per year

- Outreach & monthly reminders for tire check and inflate:
  - At least one time during the year

- On average, tires lose one psi per month

- Fuel efficiency is reduced one percent for every three psi of under-inflation (average of all four tires)

Emission Benefits
Check and Inflate

- Fuel Savings Equation
  = FGC – FGC/(1+*IFE*)

FGC = Forecasted Gasoline Consumption (from EMFAC2007)

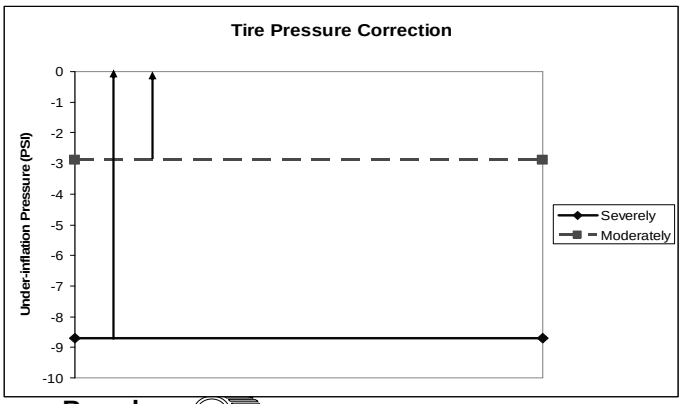
"1" = represents fuel efficiency w/out the proposed regulation

IFE = Increase in Fuel Efficiency w/proposed regulation (expressed as a decimal)

Emission Benefits
Check and Inflate

Passenger cars example:

- 20% severely under-inflated average 8.7 psi
- 34% moderately under-inflated average 2.9 psi

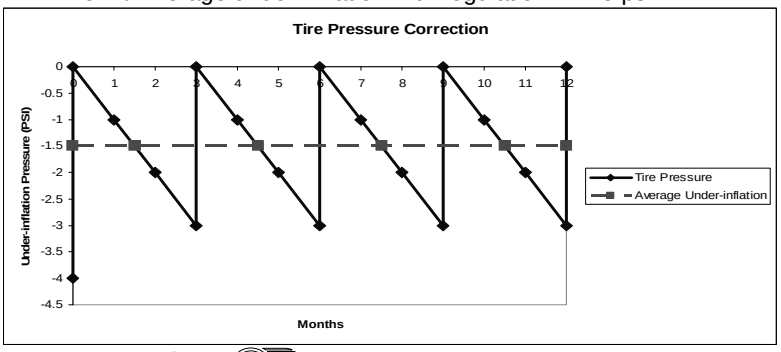


Emission Benefits
Check and Inflate

2011-2020 Tire Pressure Correction:

(Quarterly re-inflation interval)

- Expected tire pressure air loss and re-inflation interval with regulation after initial correction in 2010
- 54% Average under-inflation with regulation = 1.5 psi



Emission Benefits
Check and Inflate

- Fuel Savings Equation
  = FGC – FGC/(1+*IFE*)

Passenger cars example:

<u>For year 2010 (initial correction)</u>

- Fuel efficiency is reduced 1% for every 3 psi of under-inflation

- 20% severely under-inflated average 8.7 psi
  8.7 ÷ 3 = 2.9 → (IFE = 2.9%)

- Calculation methodology applied to passenger car and light/medium-duty truck under-inflation data

Emission Benefits
Check and Inflate

- Fuel savings
- Emission reduction
  - ~19.4 lbs of CO_2 produced for every gallon of gasoline consumed
  - Converted to Million Metric Tons (MMT) CO_2

Year	Average Annual Fuel Savings (Gallons/year)	Average Annual CO_2 Emission Reduction (MMT/year)
2010 - 2020	~ 63 million	~ 0.56

Emission Benefits
Inflation Pressure Loss Rate

- Staff studied tire composition, air permeability, and tire inner liners
- Tire inner liner
  - function is to retain compressed air
  - designed for low air and low moisture permeability
  - allows tires to be tubeless
- Researched inner liner formulations of major tire manufacturers
  - Public patents
  - Existing tire studies

Emission Benefits
Inflation Pressure Loss Rate

Example tire inner liner formulation

Ingredients	(phr)
Halobutyl Rubber	60
Natural Rubber	40
Carbon Black	60
Calcium Carbonate	40
Processing Oil	16
Stearic Acid	1
Vulcanizing Agent	1.25
Zinc Oxide	3
Magnesium Oxide	0.25
Accelerators	1.25
Total Ingredients	**222.75**
% Rubber	**44.9%**
% Halobutyl	**26.9%**
% Filler	**44.9%**

Rubber (Synthetic and Natural)

Filler material

- Analyzed 15 tire inner liner formulations
- Modification of formulations can improve (decrease) IPLR

Emission Benefits
Inflation Pressure Loss Rate

- Techniques to improve IPLR at the manufacturing level
  - Increase thickness of tire inner liner
  - Increase halobutyl rubber percentage
  - Increase filler material percentage
  - Addition of recycled rubber powders
- Major advantage is no new or additional equipment required by tire manufacturers

Emission Benefits
Inflation Pressure Loss Rate

- Increase thickness of tire inner liner
  - Advantages:
    - No new materials required
    - Formula unchanged
  - Disadvantages:
    - Increase in cost due to more material
    - Increase in tire inner liner weight

Emission Benefits
Inflation Pressure Loss Rate

- Increase halobutyl rubber percentage

- ExxonMobil Chemical Study:
  - Increase of 20 phr halobutyl rubber with corresponding decrease in natural rubber can lower IPLR 0.5 to 0.6%
  - Advantages:
    - No new materials required
    - Overall tire inner liner weight same
  - Disadvantages:
    - Increase in cost due to higher halobutyl rubber cost

Emission Benefits
Inflation Pressure Loss Rate

- Increase filler material (Carbon Black, Silica, Clay, Talc, Calcium Carbonate)
  - Filler material provides more barriers to permeating air
  - Advantages:
    - No new materials required
    - Filler material inexpensive
    - May decrease formulation cost
  - Disadvantages:
    - Too much filler may require more oils
    - Oils increase permeation rate

Emission Benefits
Inflation Pressure Loss Rate

- Addition of Recycled Rubber Powder
- Malcolm Pirnie, Inc. 2007 study:
  - Addition of Engineered Rubber Powder decreased air permeability
- Lehigh Technologies presentation in June 2008
  - Akron Rubber Development Laboratory air loss test showed a 19 percent decrease in air loss/month

Emission Benefits
Inflation Pressure Loss Rate

- Addition of Recycled Rubber Powder
  - Advantages:
    - Utilizes existing formulas
    - Promotes recycling of scrap tires
  - Disadvantages:
    - May increase cost for additional material

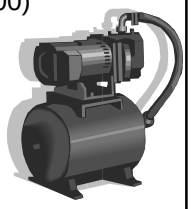
Emission Benefits
Inflation Pressure Loss Rate

- Emission benefits additional to Check and Inflate benefits
- Benefits result of tires losing air at a slower rate than the assumed 1 psi loss per month
- Estimated for IPLR = 1.5%, 2.0%, 2.5%

IPLR Performance Standard	2020 Annual Fuel Savings (Gallons/year)	2020 Annual CO_2 Emission Reduction (MMT/year)
1.5%	~ 46 million	~ 0.41
2.0%	~ 32 million	~ 0.28
2.5%	~ 18 million	~ 0.16

Regulatory Costs
Check and Inflate

- Capital Costs
  - Air compressors w/5 year service life ($400-500)
  - Air tools and hoses ($50-70)
  - ANSI Commercial Grade "B" gauges ($10-25)
  - Tire Guide/Yearbook ($20-80)



- Maintenance Costs
  - Annual compressor maintenance ($40)
  - Annual repair/replacement of air tools and hoses ($50-70)

- Labor Costs
  - Labor for check and inflate procedure
  - Estimated $2 per vehicle based on five minutes labor

Regulatory Costs
Check and Inflate

- Capital and Maintenance costs
  - 2,000 to 2,100 test-only smog check facilities
    - Average annual cost of ~$500 per facility
  - Total annual cost for all ARDs
    - Average annual cost of ~$2 million

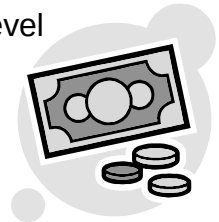
- Labor costs
  - Estimated ~25 to 29 million passenger cars, light-duty vehicles subject to regulation
  - Staff estimates a vehicle will visit an ARD about 3 times per year
  - 5 minutes to check/inflate, ~$2 per vehicle
  - Average annual costs of ~$178 million per year

Regulatory Costs
Check and Inflate

- Fuel Savings
  - Average annual fuel savings of ~ 63 million gallons of gasoline
  - Average annual savings of ~ $213 million
- Total Average Annual Cost
  - Capital, Maintenance, and Labor Cost
  - Average annual cost of ~ $180 million
- Net Average Annual Savings of $33 million
- Costs are in 2007 equivalent expenditure dollars

Regulatory Costs
Inflation Pressure Loss Rate

- Estimated costs resulting from techniques to decrease IPLR at the manufacturing level
- Determine cost of each tire inner liner formulation



- Determine cost of individual ingredients
  - Individual ingredient changes results in changes in overall tire inner liner cost

Regulatory Costs
Inflation Pressure Loss Rate

Example tire inner liner formulation

Ingredients	(phr)
Halobutyl Rubber	60
Natural Rubber	40
Carbon Black	60
Calcium Carbonate	40
Processing Oil	16
Stearic Acid	1
Vulcanizing Agent	1.25
Zinc Oxide	3
Magnesium Oxide	0.25
Accelerators	1.25
Total Ingredients	**222.75**
% Rubber	**44.9%**
% Halobutyl	**26.9%**
% Filler	**44.9%**

- Average tire inner liner weight
  - 1.85 pounds passenger tire
  - 3.5 pounds light truck tire
- Based on parts per hundred rubber (phr)
- Rubber to equal 100 phr
- Ingredients based on 100 phr
  - 3% Zinc Oxide = 3 phr
- Weight percentage of halobutyl rubber:
  60 ÷ 222.75 = 0.269 (26.9%)
- Weight of halobutyl rubber
  0.269 X 1.85 = 0.50 lbs

Regulatory Costs
Inflation Pressure Loss Rate

- Estimated cost of tire inner liner
  - (Ingredient weight) X (Ingredient cost per pound)
    - Ingredient cost obtained from distributors and manufacturers. List price.
  - Sum all ingredient costs
  - Average inner liner cost
    - Passenger car tire = $2.53
    - Light/medium-duty truck tire = $4.78

Regulatory Costs
Inflation Pressure Loss Rate

- Increasing inner liner thickness
  - Cost increase due to additional material
    - Passenger car tire = $0.25 to $0.63 (M)
    - Passenger car tire = $1.25 to $3.15 (R)

- Increasing Halobutyl Rubber +20 phr
  - Cost increase due higher material cost
  - Cost offset due to less Natural Rubber
    - Passenger car tire = $0.11 (M)
    - Passenger car tire = $0.55 (R)

(M) Manufacturing Level

(R) Retail Level

Regulatory Costs
Inflation Pressure Loss Rate

- Increasing filler material
  - Lack of information regarding filler content and IPLR reduction
  - Estimated reduction in formulation cost

- Addition of Recycled Rubber Powder
  - 5 to 10% loading
  - Cost increase due additional material
    - Passenger car tire = $0.09 to $0.19 (M)
    - Passenger car tire = $0.45 to $0.95 (R)

(M) Manufacturing Level

(R) Retail Level

Regulatory Costs
Inflation Pressure Loss Rate

- Summary of IPLR Reduction Techniques

Technique	Advantages	Disadvantages	Cost/Tire Manufacturing	Cost/Tire Retail
Increase Inner Liner (Example: 10%-25%)	No new materials or equipment	Increased cost, weight reduction elsewhere	$0.25 to $0.63 (P) $0.48 to $1.20 (LT)	$1.25 to $3.15 (P) $2.40 to $6.00 (LT)
Increase Halobutyl 20 phr	No new materials or equipment	Increased cost	$0.11 (P) $0.20 (LT)	$0.55 (P) $1.00 (LT)
Increase Fillers	No new materials or equipment. Decreased cost.	Decreased processability	Estimated < Halobutyl Costs	Estimated < Halobutyl Costs
Addition of ERP rubber	No new equipment	New material. Increased cost. More testing.	$0.09 to $0.19 (P) $0.18 to $0.35 (LT)	$0.45 to $0.95 (P) $0.90 to $1.75 (LT)

Regulatory Costs
Inflation Pressure Loss Rate

- Assumptions
  - 20% of vehicles will replace tires annually
  - Tires are replaced approximately every 4 to 5 years
- Estimated Cost
  - Based on IPLR: 2.5% → 1.5%
  - Cost per tire:
    - ~$4 to $7 per passenger car tire
    - ~$7 to $14 per light/medium-duty truck tire
  - 2020 Average Annual Cost
    - $28 million to $55 million

Regulatory Costs
Inflation Pressure Loss Rate

- Fuel Savings (2020)
  - Average annual fuel savings:
    ~ 18 to 46 million gallons of gasoline
  - Average annual savings range:
    ~ $65 to $168 million
- Total Average Annual Cost (2020)
  ~ $28 to $55 million
- Net Average Annual Savings
  ~ $37 to $113 million
- Costs are in 2007 equivalent expenditure dollars

Cost-Effectiveness
Check and Inflate

- Expressed in terms of costs (dollars) per unit of emissions reduced (tons)
- Cost-effectiveness

Emissions	Average Annual Costs 2010 - 2020	Average Annual Emissions Reduction 2010 – 2020	Total CO_2 Cost-Effectiveness
CO_2	~ $180 million	~ 0.56 MMT	~ $292/ton

Cost-Effectiveness
Inflation Pressure Loss Rate

- Expressed in terms of costs (dollars) per unit of emissions reduced (tons)

- Cost-effectiveness

IPLR	Average Annual Costs 2020	Average Annual Emissions Reduction 2020	Total CO_2 Cost-Effectiveness
1.5%	~ $55 million	~ 0.41 MMT	~ $122/ton
2.0%	~ $41 million	~ 0.28 MMT	~ $132/ton
2.5%	~ $28 million	~ 0.16 MMT	~ $158/ton

Enforcement

- Check and Inflate Regulation
  - ARB will enforce Regulation
  - Regular audits through State Agency partnerships
  - Automobile Repair Dealers will be responsible for non-compliance

- Inflation Pressure Loss Rate Regulation
  - Manufacturer self-certification
  - Test method ASTM F1112-06
  - Random testing of tires bought from retail facilities

Outreach Coordination

- California State Fair
  - 13,000 Fair Booth Visitors
    - Handed out 3,000 tire gauges
    - Collected 1,100 email addresses for check and inflate monthly email reminder list serve
  - Outreach Partnerships
    - Integrated Waste Management Board
    - Rubber Manufacturers Association
  - Future Outreach

Timeline

- Research and Outreach - Ongoing
- Additional Workshops – TBD
- Staff Report Draft Regulation – January 2009
- Board Consideration – March 2009

Action Items
Future Meetings/Contact Info

- Action Items
- Contact Information:
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